45th Weather Squadron
Space Weather Support to Launch

Space Weather Workshop, 29 April 2016

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Launch Weather Officer
Cape Canaveral Air Force Station

Our Mission

"Exploit the Weather to Assure Safe Access to Air and Space"

Delta

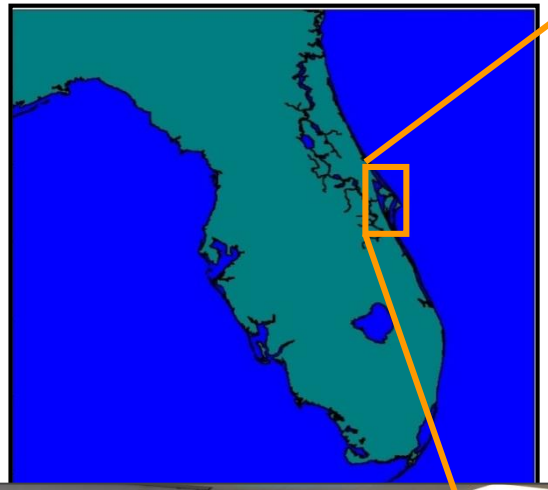
Atlas

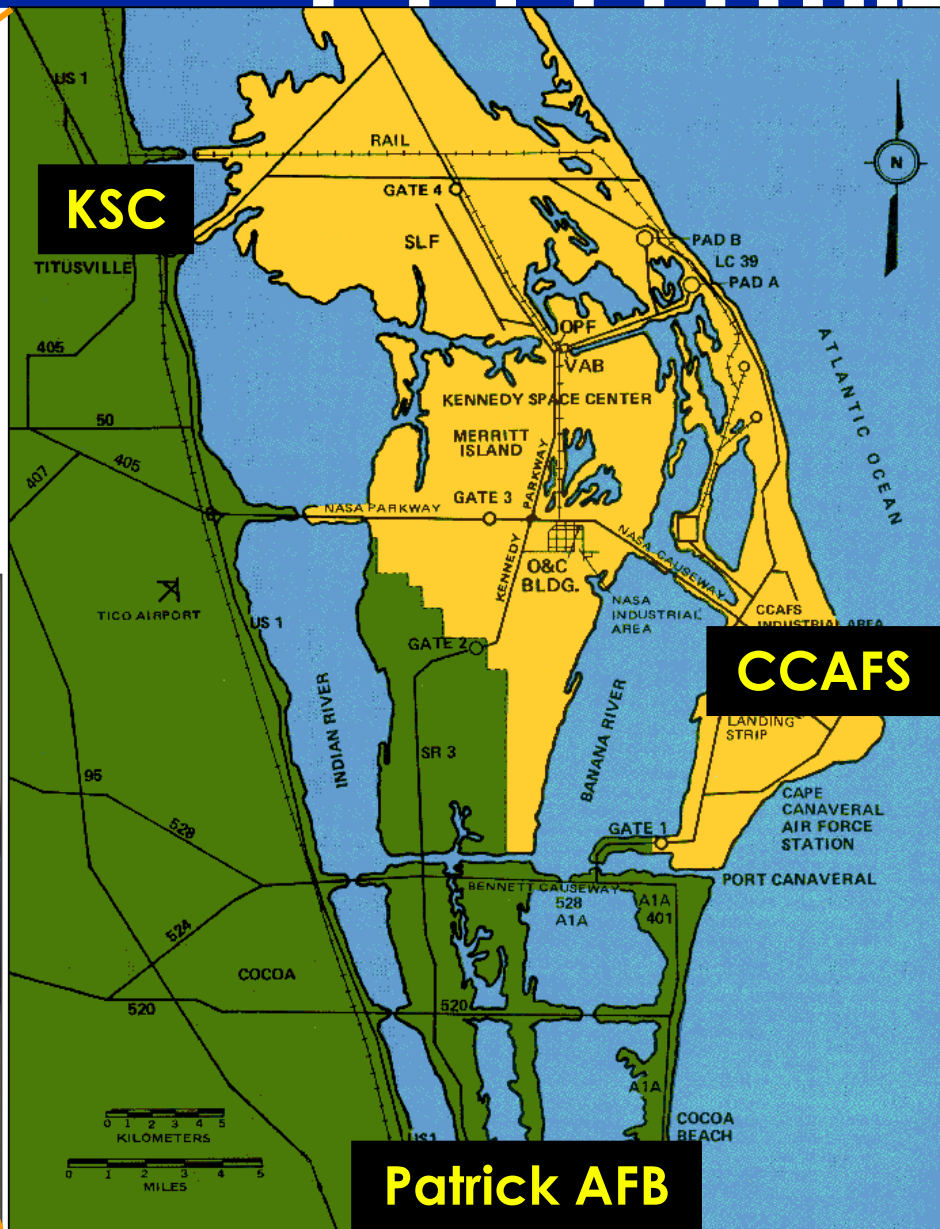
Falcon

Trident

Background

Florida Spaceport



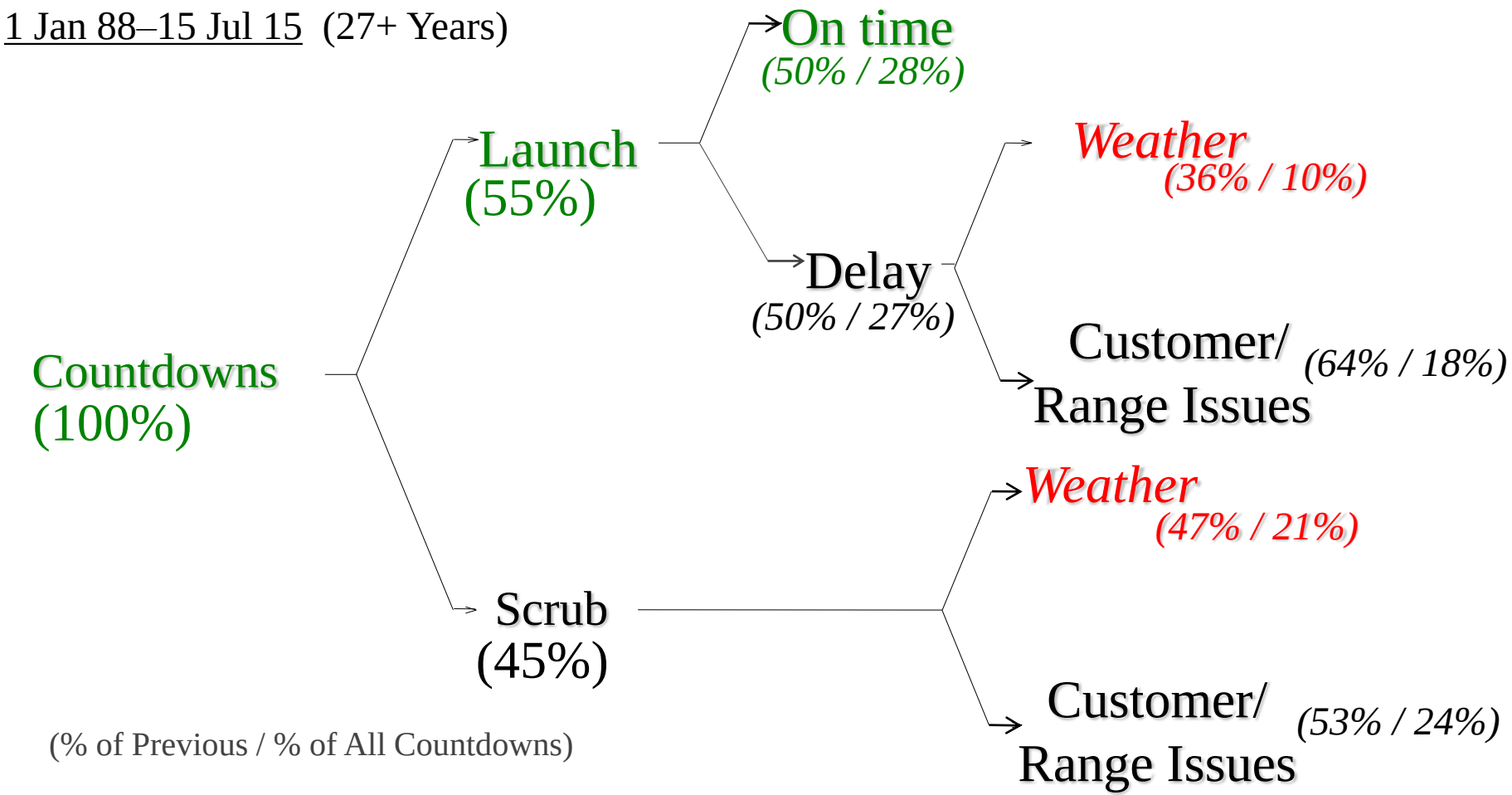


Background

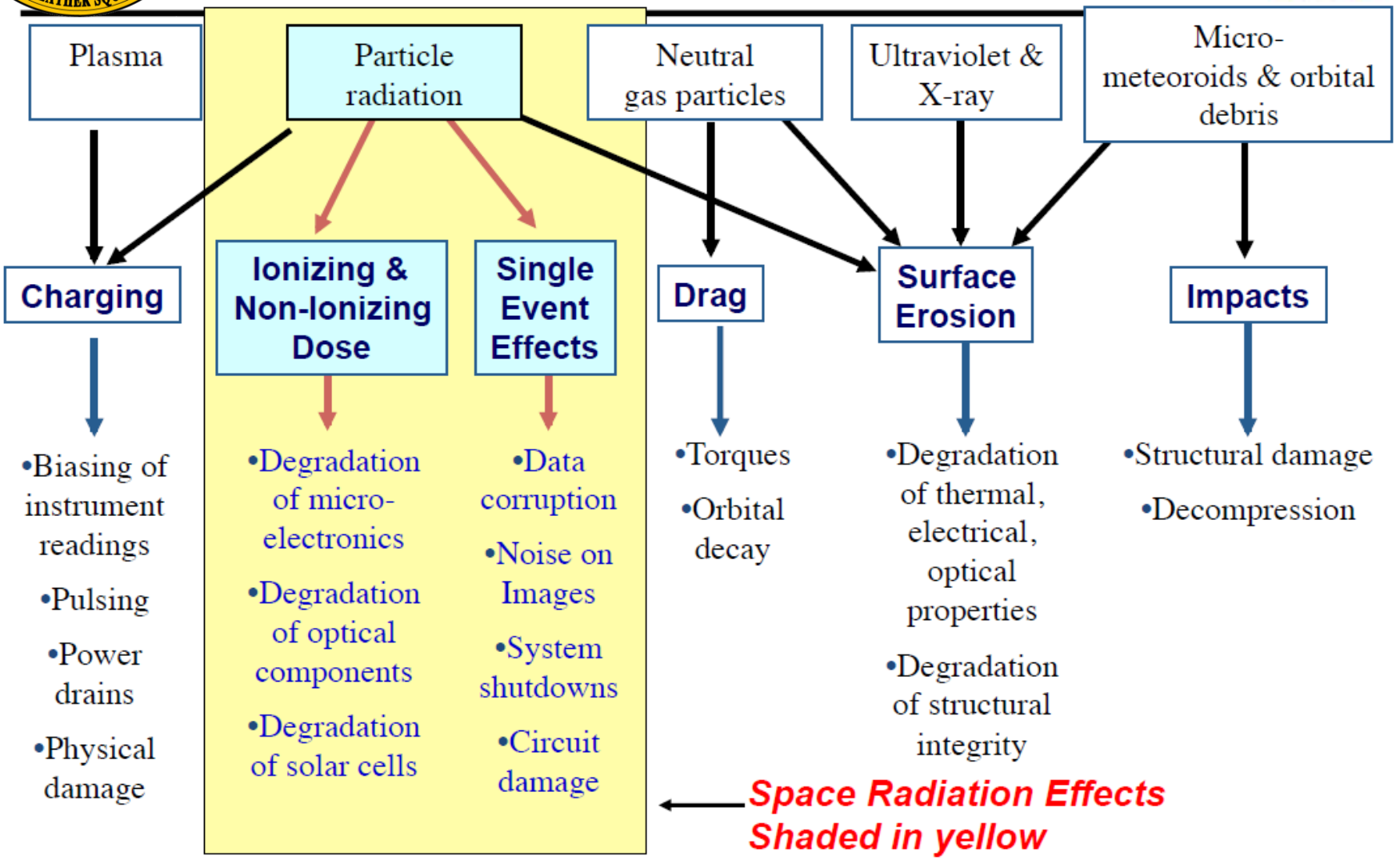
- **Weather Impacts**
  - **Launch Operations**
  - **Ground Operations**
  - **Aviation Missions**
  - **Special Missions**

Weather Impacts to Launch

- Over a third of launch delays due to weather
- Nearly half of launch scrubs due to weather



Why is Solar Weather a Concern for Launch?



Source: http://ccmc.gsfc.nasa.gov/support/SWREDI/bootcamp/tutorials-15.php

Why is Solar Weather a Concern for Launch?

For example, for Solar Radiation Storms:

Scale	Description	Effect	**Physical measure** (Flux level of >= 10 MeV particles)	**Average Frequency** (1 cycle = 11 years)
S 5	**Extreme**	**Biological:** Unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. **Satellite operations:** Satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage to solar panels possible. **Other systems:** Complete blackout of HF (high frequency) communications possible through the polar regions, and position errors make navigation operations extremely difficult.	10^5	Fewer than 1 per cycle
S 4	**Severe**	**Biological:** Unavoidable radiation hazard to astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. **Satellite operations:** May experience memory device problems and noise on imaging systems; star-tracker problems may cause orientation problems, and solar panel efficiency can be degraded. **Other systems:** Blackout of HF radio communications through the polar regions and increased navigation errors over several days are likely.	10^4	3 per cycle
S 3	**Strong**	**Biological:** Radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. **Satellite operations:** Single-event upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely. **Other systems:** Degraded HF radio propagation through the polar regions and navigation position errors likely.	10^3	10 per cycle
S 2	**Moderate**	**Biological:** Passengers and crew in high-flying aircraft at high latitudes may be exposed to elevated radiation risk. **Satellite operations:** Infrequent single-event upsets possible. **Other systems:** Small effects on HF propagation through the polar regions and navigation at polar cap locations possibly affected.	10^2	25 per cycle
S 1	**Minor**	**Biological:** None. **Satellite operations:** None. **Other systems:** Minor impacts on HF radio in the polar regions.	10	50 per cycle

Source: Space Weather Prediction Center, http://www.swpc.noaa.gov/noaa-scales-explanation

Space Weather Monitoring

Daily review of solar weather and expected impacts

UNCLASSIFIED

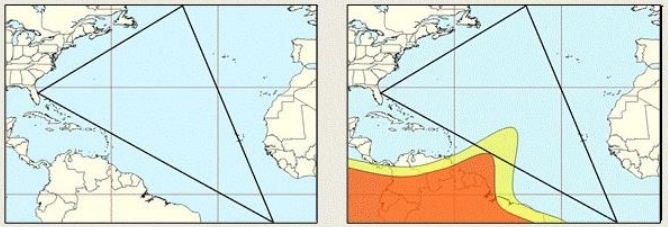
Eastern Range Space Environment Situational Awareness

557TH WEATHER WING

Valid: 22-Sep-2015 0600Z

	Today 22-Sep			3 - Day Forecast 23-Sep			24-Sep			25-Sep		
	night	day	night	night	day	night	night	day	night	night	day	night
HF Comm												
UHF SatComm												
High Alt Flight Radiation												
Radar Interference												
GPS Error (Single Freq)												

No Impacts | Impacts Possible | Impacts Likely



HF Forecast Valid: 22/0600Z --- 22/1200Z

UHF Forecast Valid: 22/0600Z --- 22/1200Z

Space Weather Impacts Summary **Solar Flare Probabilities:** M: 40% X: 05% P: 10%

HF Comm (YELLOW or RED): Temporarily degraded or total loss of HF radio communications.

Forecast GREEN - 22 - 25 Sep during all hrs.

UHF SatComm (YELLOW or RED): Temporarily degraded or total loss of UHF radio communications.

Forecast RED (Severe Scintillation) - 22 - 25 Sep during night hrs.

Forecast GREEN - 22 - 25 Sep during day hrs.

High Alt Flight Radiation (YELLOW or RED): Increased harmful radiation dosage to personnel in high altitude operations.

Forecast GREEN - 22 - 25 Sep during all hrs.

Radar Interference (YELLOW or RED): Increased interference or false returns to sunward and poleward looking radar.

Forecast GREEN - 22 - 25 Sep during all hrs.

GPS Error (Single Freq) (YELLOW or RED): Temporarily degraded or total loss of GPS signal.

Forecast YELLOW (Errors 15-50 Meters) - 22 - 25 Sep during night hrs.

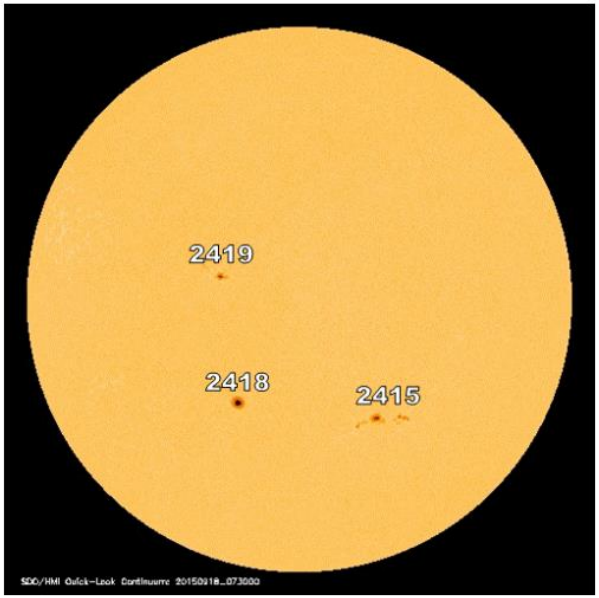
Forecast GREEN - 22 - 25 Sep during day hrs.

MAXWELL / BOLTON Issued: 22-Sep-2015 0600Z

Prepared by 2 WS/WXZ DSN 272-8087 COMM (402) 232-8087

For more detailed information go to:

https://weather.af.mil/confluence/display/AFWWEBSTBT/Space+Weather+Main+Page https://weather.af.smil.mil/confluence/display/AFWWEBSTBT/Space+Weather+Main+Page



Solar Region Summary

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AXXX02 KWNP 180030
Joint USAF/NOAA Solar Region Summary
SRS Number 261 Issued at 0030Z on 18 Sep 2015
Report compiled from data received at SWO on 17 Sep
I.  Regions with Sunspots.  Locations Valid at 17/2400Z
Nmbr Location  Lo  Area  Z   LL   NN Mag Type
2415 S20W16   235  0230 Eac  11   30 Beta-Gamma
2418 S14E19   200  0210 Cso  07   04 Beta
2419 N12E21   198  0100 Cao  06   08 Beta
IA. H-alpha Plages without Spots.  Locations Valid at 17/2400Z
Nmbr  Location  Lo
None
II. Regions Due to Return 18 Sep to 20 Sep
Nmbr Lat    Lo
None
```

Forecasting Space Weather for Launch

- **Observe current sun spot complexity and location**
- **Review recent space weather events (i.e. CMEs, Solar Flares)**
- **Review Air Force 557 WW (formerly AFWA) and NOAA Space Weather Prediction Center (SWPC) products (Goddard too!)**
- **Indicate Solar Weather is Low/Moderate/High on L-3, L-2, and L-1 Launch Forecasts**

Launch Mission Execution Forecast

Vehicle: Delta IV GPS IIF-5
Issued: 19 February 2014/1300Z (0800 EST)
Valid: 21 February 2014/0140Z – 0159Z (20/2040 – 2059 EST)
Launch Weather Team: (321) 853-8484

Synoptic Discussion: A cold front is moving through to the north, and the high pressure area that was to the north yesterday is moving off into the Atlantic Ocean. The associated high pressure ridge will move over Central Florida keeping winds light. Warm temperatures will cause an afternoon sea breeze, but conditions are dry and weather will remain favorable today during pre-launch operations. On launch day, an upper-level ridge will build in and the surface high pressure ridge will move to the north causing breezy southeasterly flow, but not strong enough to cause concern for launch operations. Some cumulus clouds may develop along convergent bands moving in from offshore, but only low-level moisture is expected; therefore, this is not a significant concern for launch. As for solar activity, a geomagnetic event is in progress and proton flux levels are elevated but are well below the proton flux constraint for launch. A complex sunspot could cause a solar flare, and an X-Class flare would cause a proton flux concern. There is a 5% chance of an X-Class flare during the next 48 hours. **The primary concern for launch is cumulus clouds and solar activity.** Friday, a cold front will move into Central Florida and will stall for a few days. The atmosphere will become more unstable, and showers and thunderstorms are possible, particularly in the afternoon. Due to the weather expected Friday, the probability of violating weather constraints for a 24-hour delay increased to 40%.

Clouds	Coverage	Bases (feet)	Tops (feet)
Cumulus	Few	3,000	5,000

Weather: None
Visibility: 7 miles
Wind: 150° @ 14-20 KT (306')
Temperature: 69° F
Solar Activity: Moderate
Pressure: 30.13 INS
RH: 87%

Launch day overall probability of violating weather constraints: 20%
Primary concern(s): Cumulus Clouds, Solar Activity

24-hour delay overall probability of violating weather constraints 40%
Primary concern(s): Cumulus Cloud, Lightning, Flight Through Precipitation

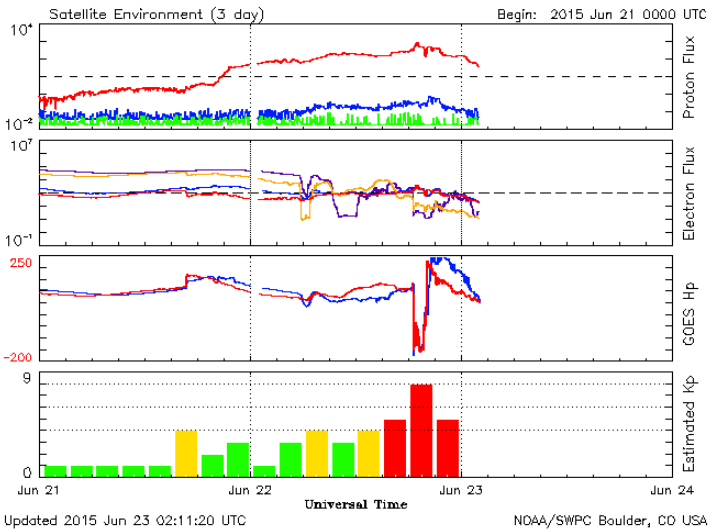
Sunrise: 20/0656 EST, 21/0655 EST
Sunset: 20/1817 EST, 21/1817 EST

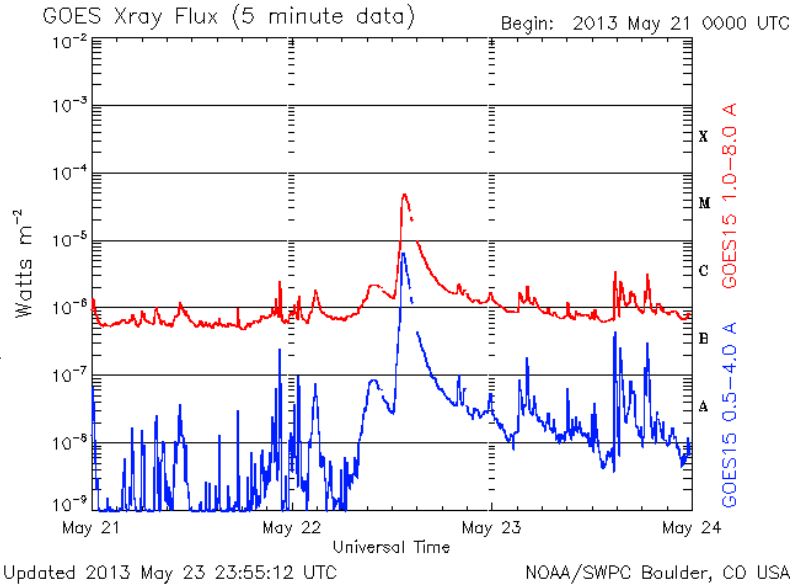
Moonrise: 20/2338 EST, 22/0036 EST
Moonset: 21/1051 EST, 22/1140 EST
Illumination: 20-21 Feb 71%, 22 Feb 61%

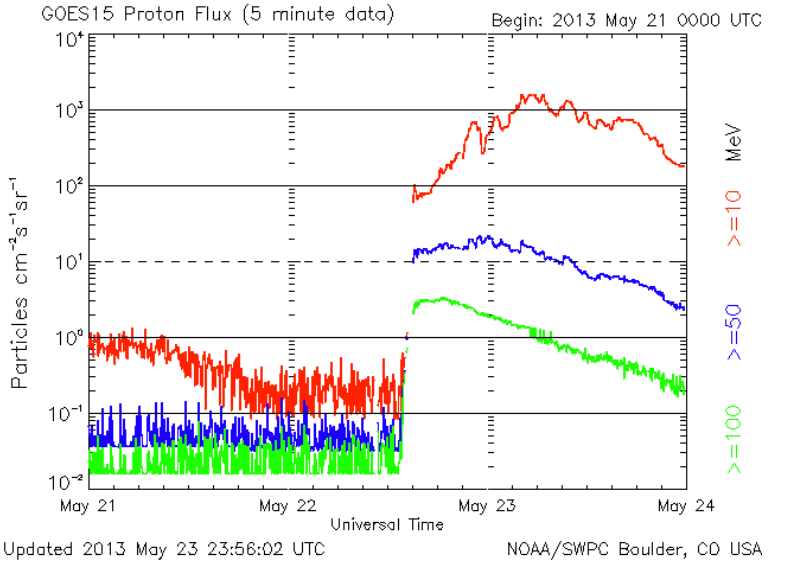
Next forecast will be issued: As Needed

Monitoring Space Weather for Launch

- **Launch Weather Officer contacts 557 WW Space Weather Operation Center for update**
- **Monitor live data during the launch countdown. Report space weather to customer during periodic briefings during the countdown**
- **Report any trends toward or violations of customer space weather constraints**
- **Customer determines whether or not they will launch given the situation**

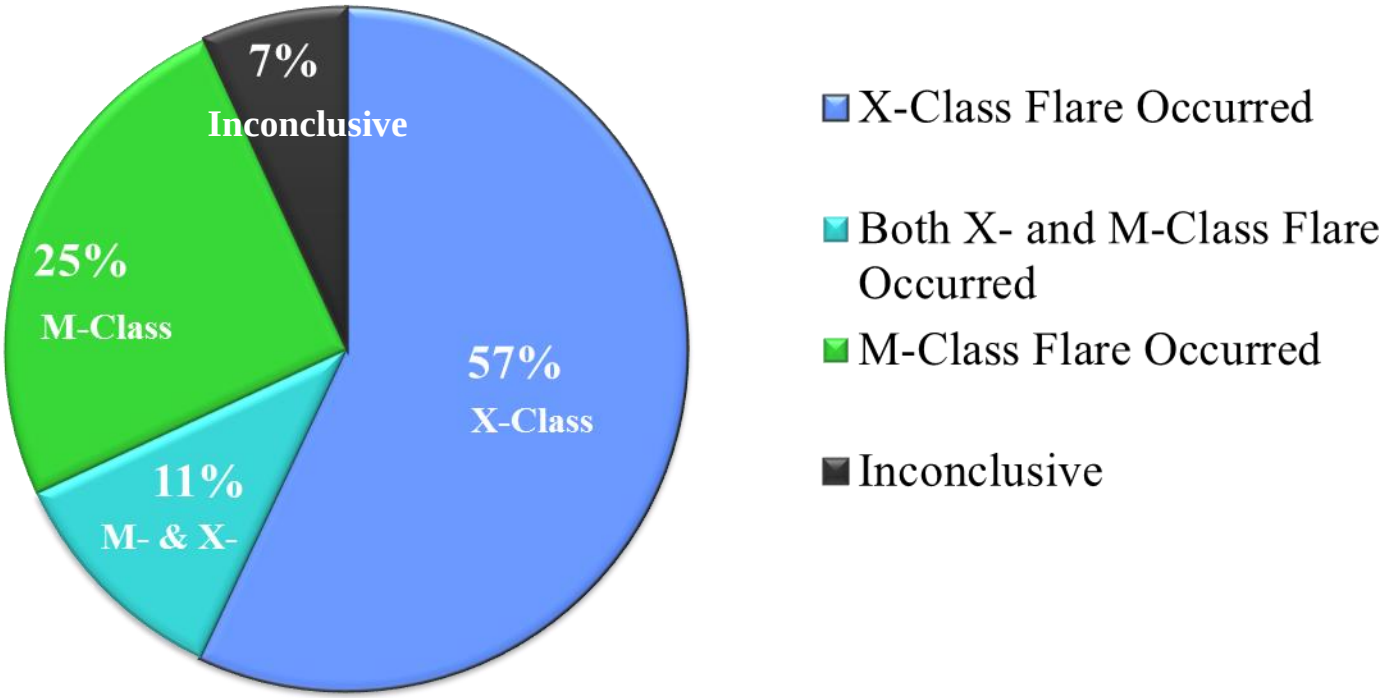






Eastern Range Launch Related Events

Exceeding Constraints:
X- or M-Class Flares Preceded

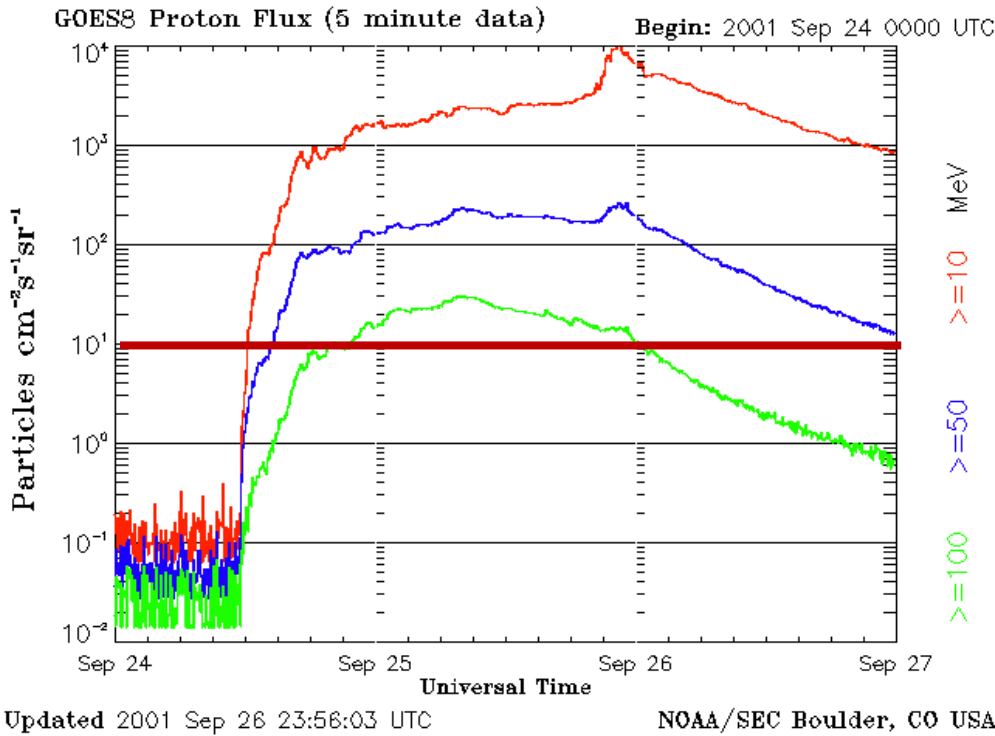


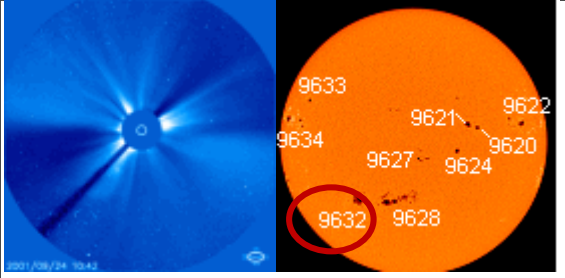
June 2, 1996 – Sep 22, 2015

Example: Kodiak Launch Sep 2001

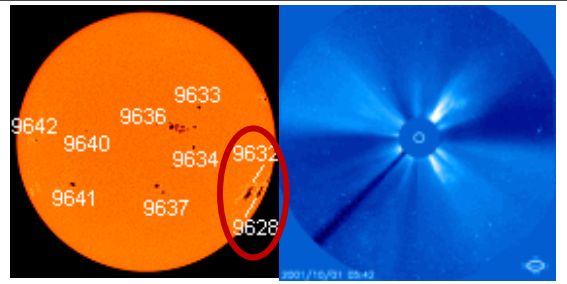
Timeline

- **Sep 21: Scrub due to winds gusting to 45 knots**
- **Sep 22: Scrub due to mandatory telemetry radar system down**
- **Sep 23: Thick Cloud and low-cloud ceiling scrubbed launch**
- **Sep 24: Weather looked promising until X-class solar flare erupted**
  - **Constraint = 10 MeV Proton Flux < 10pfu**
  - **Result: 5 day launch delay to protect sensitive avionics**
- **Sep 29: Launch and successful deployment of 4 satellites**

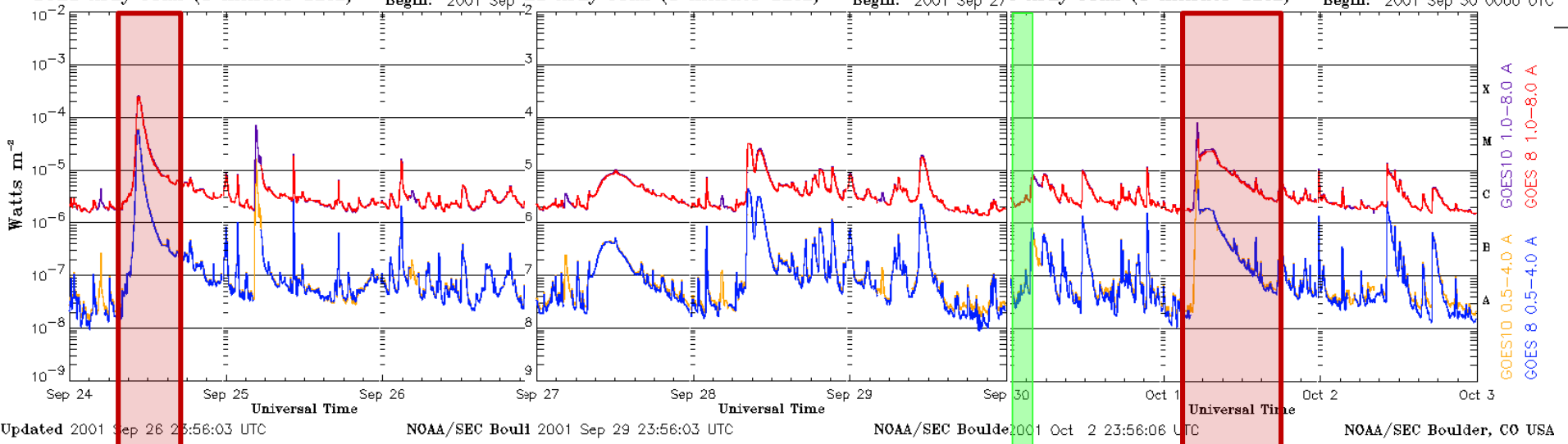




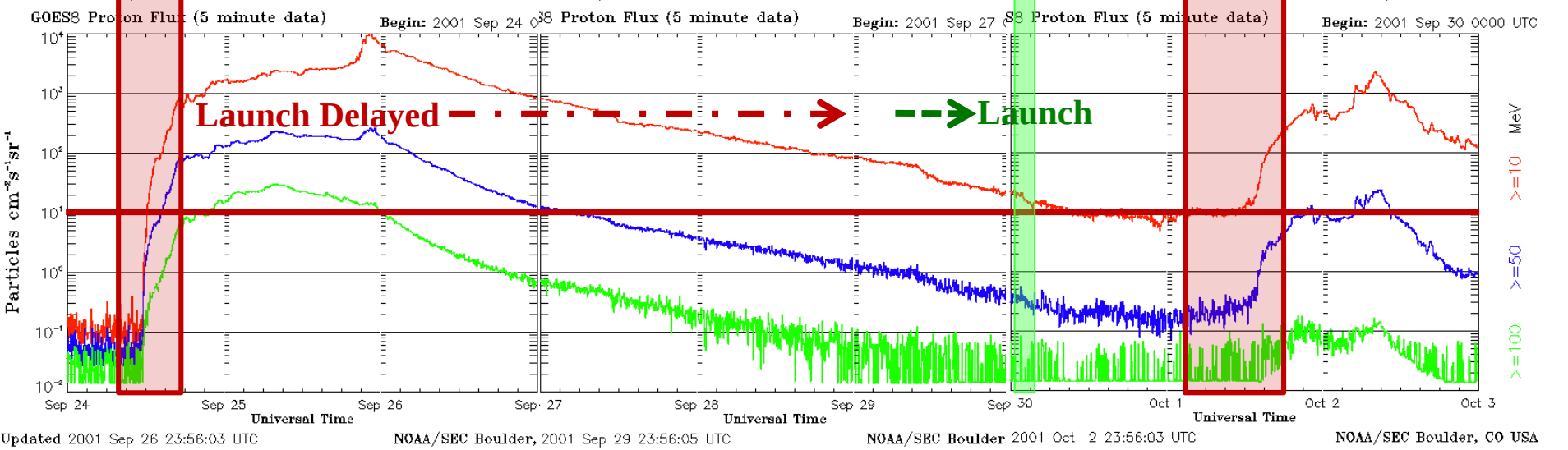
Data: Kodiak Launch 2001



Flare



Flare



Questions?

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